AD-786 611

HAPREX PLANNING

R. Hendrick, Jr., et al

Mission Research Corporation

Prepared for:

Ballistic Research Laboratories
General Electric Company

June 1974

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

Destroy this report when it is no longer needed.
Do not return it to the originator.

Secondary distribution of this report by originating or sponsoring activity is prohibited.

Additional copies of this report may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151.

A

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AD 786 611

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CONTRACT REPORT NO. 164	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HAPREX PLANNING		5. TYPE OF REPORT & PERIOD COVERED Memorandum Report Jun - Dec 73
		6. PERFORMING ORG. REPORT NUMBER MRC-R-108
7. AUTHOR(s) R. Hendrick, Jr. T. Barrett (GE-TEMPO)		8. CONTRACT OR GRANT NUMBER(s) DAAD05-73-C-0539
9. PERFORMING ORGANIZATION NAME AND ADDRESS Mission Research Corporation 735 State Street P.O. Drawer 719 Santa Barbara, CA 93102		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 612111.11.02100 RDTE 1T162111A116
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Materiel Command 5001 Eisenhower Avenue Alexandria, VA 22333		12. REPORT DATE Jun 74
		13. NUMBER OF PAGES 12
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) US Army Ballistic Research Laboratories Aberdeen Proving Ground, MD 21005 (Dr. L. J. Puckett, AMXBR-CA)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Striated Atmospheric Ionization
Barium Cloud Striations
SECEDE
Barium Cloud Ionization
Radar Effects
Barium Plasmas
Ionospheric Wind Effects
Wind Induced Striations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A survey of HAPREX test objectives and first results is presented, the physical mechanisms controlling the striation of the barium ion cloud are described, and an alternative test configuration is outlined.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

SECTION I

HAPREX PLANNING

HAPREX is an ABMDA-sponsored project dealing with studies of the effects of high altitude striated ionization on radar performance. This project employs barium clouds, released at high altitudes, which are ionized by solar radiation and striated by gradient drift forces produced by winds and $\vec{E} \times \vec{B}$ forces.

The use of barium was originally sponsored by ARPA under Project SECEDE. ABMDA continued this sponsorship to assist in the development of assessment and mitigation techniques to optimize BMD radar system performance in a nuclear environment.

HAPREX has been planned as a three test series program:

WEATHERVANE - A series of releases held at Kwajalein in 1973 to determine the atmospheric conditions associated with barium releases at low latitude.

SUNDIAL - A series of releases to determine optimum release conditions, that is, minimum striation times and maximum integrated electron content through a large, striated cloud.

HOURGLASS - A test release wherein an RV, launched from Vandenberg AFB, accompanied by chaff, tanks, decoys, etc., would be tracked behind a striated barium cloud to test algorithms designed to discriminate in a nuclear environment.

To date, Weathervane has been completed, Sundial is in the planning stage, and Hourglass probably will be held early in 1976.

PROGRESS TO DATE

In some respects, the Weathervane tests were a failure; however, in others the test results support the judiciousness of the project planners. The four releases made during this series are described in Table 1 from Reference 1. Two standard (48 kg) releases were used as well as two low yield (1 kg) puff releases. Striation times were very long, with resulting low electron content. Project SECEDE results show that typical releases achieve peak electron concentrations in about 30 seconds at levels on the order of 1 to 2×10^7 cm^{-3}. Thereafter N_e falls off as $t^{-1/2}$, by diffusion. Striation times are apparently governed by the magnitude of the vector

$$\vec{v} = \vec{E} \times \vec{B} - \vec{v}_n \tag{1}$$

where $\vec{E}$ and $\vec{B}$ are the local electric and magnetic fields and $\vec{v}_n$ is the wind velocity at the cloud. At Kwajalein in June this net vector $\vec{v}$, is small, hence striation times are larger than at higher latitudes.*

The Weathervane series clearly showed that single barium releases, in June, would not produce striated ionization levels sufficient to significantly perturb the radar signals of interest.

Sundial and Hourglass Planning

A week-long meeting was held at Albuquerque in the summer of 1973 to review the data from Weathervane and to prepare plans for Sundial. In addition, a tentative plan for Hourglass was to be formulated. General Electric-TEMPO participated in the early stages of the Hourglass planning

* A crude estimate of striation time is $t_s \sim d/v$ where v is given by Equation 1 and d is a characteristic cloud dimension.

Table 1

PROJECT HAPREX--WEATHERVANE TEMPORAL HISTORY

Event	Ion Cloud Extends Beyond Neutral	Apparent Ion-Cloud Steepening	Striation Onset	Neutral Cloud Faded	Ion Cloud Faded
Weathervane I*	1 min 33 s	5 min 57 s (East) 4 min 13 s (West)	15 min 21 s	17 min 21 s	22 min 4 s
Weathervane II	42 s	--	--	22 min 7 s	28 min
Weathervane III*	56 s	--	--	17 min 57 s	16 min 17 s
Weathervane IV	23 s	3 min 21 s	4 min 51 s	14 min 1 s	32 min 7 s

* Times after second release.

and assisted as a sub-chairman (T. J. Barrett), on the final Sundial Planning Committee. A second review meeting was held at Stanford Research Institute in September. Several significant factors were developed in each of these planning sessions.

Sundial

1. Standard releases would probably not provide the desired integrated electron content in a heavily striated environment.
2. Sundial should definitely employ one or two slab releases, as recommended by Linson, to produce early striation times. Linson's theory (Reference 2) indicates that a series of four 16 kg releases, released in a plane perpendicular to the plane of the vector $\vec{v}$ described in Equation 1 would striate in roughly one-fourth the time of a single 48 kg release. This geometry is referred to as the "slab" geometry.
3. In order that the slab geometry receive a fair test, a series of puff releases should be made prior to the slab release to determine the plane of the vector $\vec{v}$ as described earlier.
4. In the event that the slab theory fails to produce early striations, contingency plans are required. These include the use of several (perhaps 4 to 6) independent clouds, released in the cross-trajectory plane, at early times (relative to sunset). These individual clouds hopefully would provide the intense striated environment required to test the algorithms in question.

CLOUD CONFIGURATION AND GEOMETRY

For Sundial, the releases will be held at 185 to 195 km altitude and approximately 100 km to the northeast of the Kwajalein atoll. The Nike-Tomahawk can be used at this close-in range. For Hourglass, the releases also would be at 185 km altitude but would be located some 400 km northeast of the atoll so that the clouds would intersect the radar's line of sight to

RV's launched from Vandenberg AFB. A Strypi-II rocket will probably be required for these releases.

To provide beam filling of the 2.8° Altair antenna pattern, the extent of the cloud perpendicular to the line of sight would have to be on the order of 20 km. This extent may be difficult to achieve (depending on the orientation of the plane of the slab release). Smaller clouds (5 to 10 km) could provide interesting levels of angle scintillation and range spread which would test algorithms of interest. Such clouds should produce angle scintillations on the order of 3 or 4 mr (Altair can measure scintillation on the order of 1 mr) and produce range spreading which will double the 20 meter pulse width which is planned to be used in this experiment. The larger the cloud, of course, the longer the occultation time and the greater the probability that a successful occultation will occur

The Hourglass planning will depend heavily on the outcome of the Sundial tests. Current plans are to hold Sundial early in 1975 and Hourglass at the same month in 1976.

FUTURE PLANS

Further detailed planning for Sundial and Hourglass will be delayed until the summer of 1974. This planning will finalize details of yields, release locations and timings and instrumentation to be employed in both series. Modifications to Altair will be completed prior to the Hourglass series. Algorithms will not be tested in real time but rather data shall be recorded and used in testing both current and future algorithms designed for assessment and mitigation.

SECTION II

ALTERNATE HAPREX CONFIGURATIONS

As was discussed in Section I, Weathervane was disappointing from the standpoint of the generation of striated plasma clouds. The lack of structuring was attributed to the small ionospheric electric field at the time of the release (evening twilight). This section discusses some potential alternate plans that could assure more rapid striation of the plasma.

TEST TIMING

In the equatorial region, the source of the ionospheric electric field is primarily the vertical motion of the upper atmosphere across the essentially horizontal geomagnetic field. The air motion is caused by solar heating and expansion and tidal forces. This results in a minimum field during the normal HAPREX time. The barium cloud must be sunlit to become ionized but the lower atmosphere must be shaded if visual observations are to be easily made from the ground. This implies tests in the twilight hours. It is just then that solar heating is changing radically and the atmosphere transitioning between rise and fall.

One possibility is that recognizing the problem, more careful timing of the release in early twilight might assure striation. Ground based magnetic measurements that sense electrojet behavior might provide real time data for control of the timing of the experiment to maximize the probability of test success. The deficiency of this alternative is that the test window is much reduced and timing may be too critical to allow good coordination of the various missiles in the experiment.

A second alternative is to forego the easy ground based optics and conduct the test during daylight at the ground when solar heating is maximum. If this route is followed, alternate diagnostic measurements must be provided inasmuch as the propagation experiment has much reduced value if good diagnostic measurements of the plasma are not obtained.

Two optical measurement techniques might be used. Stanford Research Institute is currently developing on another program a laser system for making resonant backscatter observations. In discussions with them it appeared that daylight observations could be provided by using a narrow band interference filter on the receiver.

The other measurement possibility is the use of a rocket-borne optical system with either a recoverable photographic package or a television transmitter. If the plasma cloud were at 200 km and the lowest allowable sight path target altitude were 50 km, a rocket 200 km to the side of the plasma would have about 6 minutes of viewing. 370 seconds are provided if the observation system could be uncapped at 50 km or 340 seconds if it could be uncapped at 75 km. The problem is the heat flux into the camera system due to ram air heating. The heat flux stagnating the ambient air is 150 cal/cm^2 sec at 50 km and about 5 cal/cm^2 sec at 75 km altitude so the question is the amount of protection that can be provided the camera. However, the loss in observation time is not great going to the higher uncapping altitude.

The requirement on the camera system is not great. A 1 cm aperture gives a diffraction limited resolution of 10 meters at a 200 km range. Consequently, diffraction should not limit the observation. A television system with a 1000 element per sweep resolution would provide 25 meter resolution over a 25 km field of view. Inasmuch as the field can also be slowly moved, such resolution should be adequate.

ARTIFICIAL WINDS

Theoretical predictions of striation behavior indicate that if striations form, they should decay only slowly even if the mechanism providing instability disappears. Consequently, if a temporary neutral wind exists it could cause plasma structuring to provide the desired propagation environment.

A relatively inexpensive unguided rocket can carry a payload of 1000 to 2000 pounds to altitudes of several hundred kilometers. Assume for illustrative purposes that a ton (10^6 grams) can be lofted to the altitude of the HAPREX experiment. If this ton of payload was high explosive an energy of 4×10^{16} ergs would be available.

The experimental configuration visualized would detonate the high explosive 75 to 100 kilometers from the location of the barium plasma. If the atmosphere were homogeneous with a density equal to that existing at 180 km altitude, the energy available could accelerate all the air in a 75 km radius sphere to 100 meters/sec. Consequently, the outward propagating pressure wave would be at least that fast when it reached 75 km. The amount of air involved would be about 10^{-6} gm/cm^2 of wave front. This is at least 100 times the integrated plasma density so adequate material should be available to striate the plasma. It would take several minutes for the wave to reach the plasma.

If the use of an artificial wind is seriously considered, detail computations of the detonation should be made to determine the optimum location (i.e., coaltitude, above, below, etc.). The location needs optimization both from the standpoint of maximum instability and minimum reliance on detonation point precision. Still, the crude approximation used here indicates that there is a possibility of producing sufficient wind and that wind should be relatively uniform across a front comparable to the expansion radius (75 km) and the location of the detonation probably needs to be no more accurate than 10 to 20 percent of the expansion radius.

REFERENCES

1. Boquist, W. P., et al., "Operation Weathervane Optical Morphology and Cloud-Track Measurements," Results of Weathervane Test Series, Special Technical Report 1, Stanford Research Institute, Menlo Park, California, November 1973. (Unclassified).

2. Linson, L. M., "Coupling of Ion Clouds to the Neutral Wind," Proceedings of the 1971 Technical Planning Session, Vol. III, pp 1-12, RADC TR-71-200, Stanford Research Institute, Menlo Park, California, 1971 (Unclassified).